U. S. ARMY TEST AND EVALUATION COMMAND
BACKGROUND DOCUMENT

AMSTE-RP-702-100
Test Operations Procedure 1-1-007 — 1 August 1973

DESERT MAINTENANCE CONSIDERATIONS

SECTION I
GENERAL

1. Purpose and Scope.

The purpose of this document is to provide general guidance to test personnel concerning the planning, conduct and evaluation of maintenance during tests in a desert environment.

The scope is quite broad, being limited neither to a particular class of test items nor to a specific type of test. This document does not contain detailed procedures for the conduct of tests; this information is available in other Test Operating Procedures (TOP's), Materiel Test Procedures (MTP's) and other TECOM documents.

2. Basic Information.

Deserts comprise approximately 19% of the earth's land surface area. It is essential that Army materiel be suitable for military operations

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which may be performed world wide. Many attempts have been made to define the word "desert" and to classify the deserts of the world. Reference 2 provides the interested reader with discussion of these problems. Figure 1 shows the location of the world's deserts. The dark-shaded areas are core desert regions while the lighter-shaded areas represent marginal or transition desert areas.

It is noteworthy that much of the testing of Army materiel is conducted in desert areas. Yuma Proving Ground is located in a core area of the Sonora Desert. White Sands Missile Range, Fort Bliss, Fort Huachuca and Deseret Test Center are all located in marginal desert areas.

Climate and terrain are the principal considerations for desert operations. Summer day temperatures often range between 120 and 130°F. The typical clear skies and dry air permit maximum solar radiation. The absorption of this solar radiation by objects raises their temperatures well beyond the point where personnel can handle them without protection. The interaction of solar illumination and reflective terrain produces a high degree of glare.

Rain is infrequent in desert regions. Heavy rains do occur, however, with flash flooding due to the lack of vegetation to impede runoff.

The effect of the desert environment on maintenance varies widely with the type of equipment being maintained and with the maintenance echelon at which a particular action or task is to be accomplished. Specifically, desert maintenance considerations may be divided into the following areas:

a. Changes in the maintenance requirements from temperate zones requirements.

b. Dificulties which may be encountered in performing maintenance.

c. Human factors and safety aspects which may hinder maintenance. Maintenance evaluation must consider the adequacy of test item design and maintenance support planning to alleviate problems in these areas.

SECTION II
TECHNICAL PRESENTATION

3. Introduction.

Maintenance considerations are broken down into three main areas, maintenance requirements, problems and evaluation. The desert environment, heat, dirt, dust, wind, solar properties, static electricity

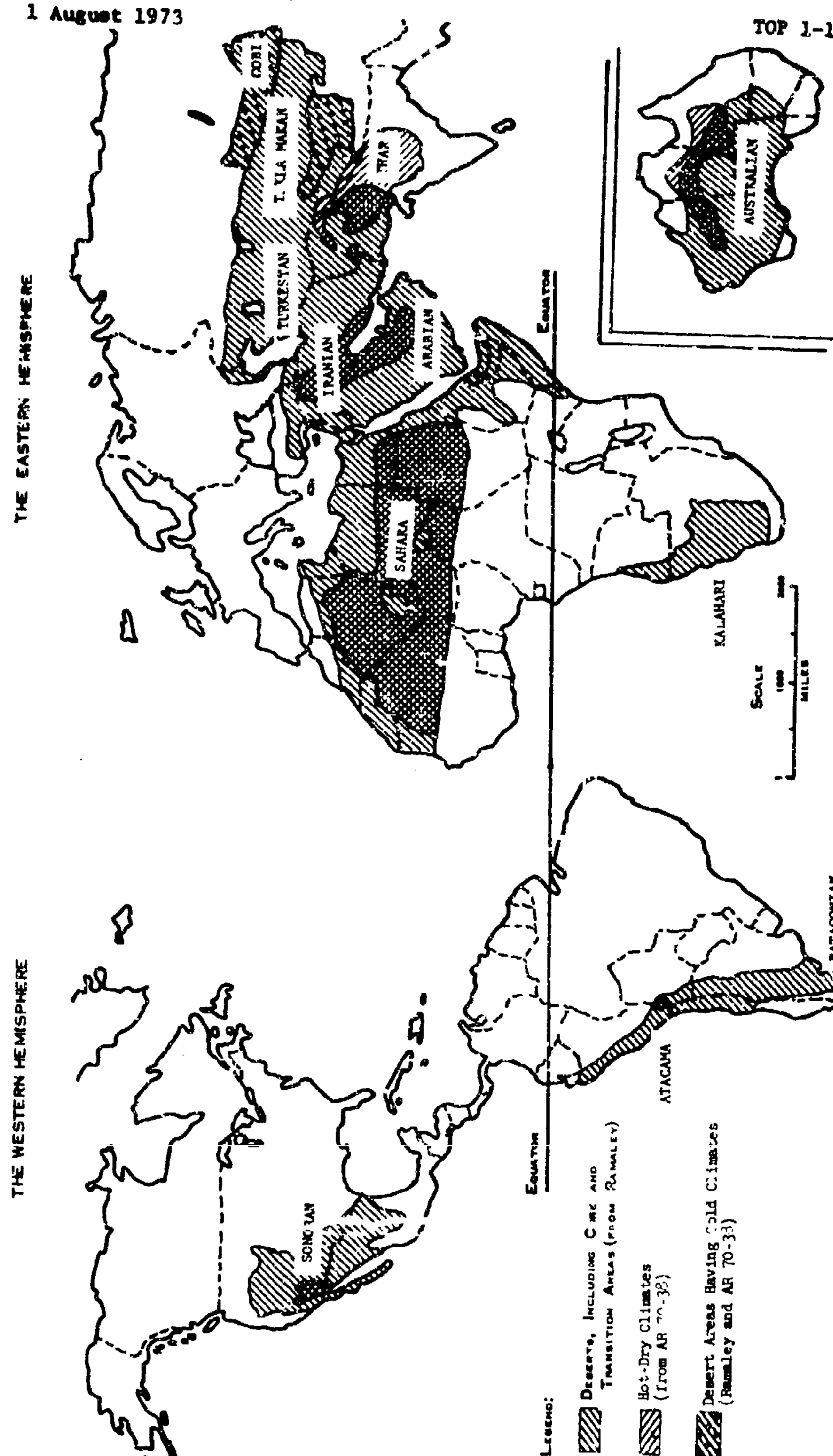

FIGURE 1

OCCURRENCE OF THE AREAS HAVING HOT-DRY CLIMATES IN RELATION TO THE WORLD'S DESERTS.

discharge, and shelters are the main considerations. The following categories were considered:

a. Wheel and tracked vehicles

b. Armament and individual weapons

c. Ammunitions and explosives

d. Missile and rocket systems

e. Electronic, avionic, and communications equipment

f. Aviation, air delivery equipment and aircraft weapons subsystems

g. Missiles and rockets

h. General equipment (chemical, biological and radiological equipment, construction, support and service equipment, general supplies and equipment). All these items may be loosely grouped with other classes of materiel. No specific desert maintenance considerations peculiar to general equipment have been identified.

4. <u>Maintenance Requirements</u>.

a. General

(1) Environment. Test personnel should be aware of the stresses imposed on equipment during operation in a desert environment in order to properly plan for maintenance and to recognize the adverse effects of the environment.

Reference should always be made to "Operations under Unusual Conditions" in the pertinent technical manuals before the start of testing. This section provides specific instructions for operations, storage and crew maintenance during extreme hot weather.

Vehicular components of rocket and missile systems are affected by the desert environment much as other wheeled and tracked vehicles. Certain additional problems may be anticipated due to the modification of a vehicle for use as a missile carrier. These additional problems usually are related to a vehicle loading characteristics and changes in airflow. Overheating of the vehicle is the most common problem.

The stony nature of many desert areas causes severe vibration while the missile system is being transported. This may affect any component of the system.

It is generally conceded that the desert is certainly the least severe of the extreme environments for operation of rockets and missile systems. The desert, furthermore, is relatively free from many of the difficulties associated with mud, rain freezing, and corrosion, which are common to temperate climates.

Desert areas are generally considered better than averages for operation of aircraft and aviation type material. Corrosion hazards are low and foul weather is unusual. There are, nevertheless, a number of adverse effects associated with operation in the desert which will increase or alter the maintenance burden.

Generally, the maintenance requirements of aircraft and subsystems are primarily due to the necessity to frequently clean and inspect in order to prevent serious damage from the environment.

Personnel conducting tests of aviation, air delivery or aircraft weapons subsystems should be thoroughly familiar with the technical manuals for the particular test item. In addition, they should be familiar with TM 55-410, "Aircraft Maintenance, Servicing and Ground Handling Under Extreme Environmental Conditions."

(2) Heat. The efficiency of lubricating oil is decreased when operated at elevated temperatures due to reduced viscosity and increased oxidation rate. (See Fig. 2) The temperature limits for lubricating oil (MIL-L-2104C) are given as follows:

(a) 250°F for sustained operation

(b) 275°F for short (15 min) periods

(c) 300°F in automatic transmission or gearbox

Gear oils (MIL-L-2015B) used in manual transmissions, transfer cases and differentials of automotive equipment should be limited to the following maximum temperatures:

(a) 250°F for sustained operation

(b) 300°F for short (15 min) periods

Hydraulic fluids conforming to the requirements of MIL-H-5606A should be kept below 160°F in open systems and 275°F in closed systems. In sealed systems pressurized with inert gas, a maximum temperature of 500°F can be tolerated for short periods (not exceeding 15 minutes).

Any lubricating oil, hydraulic fluid or brake fluid which is known to have been used at temperatures exceeding the maximum allowable temperature should be drained and replaced with fresh oil or fluid.

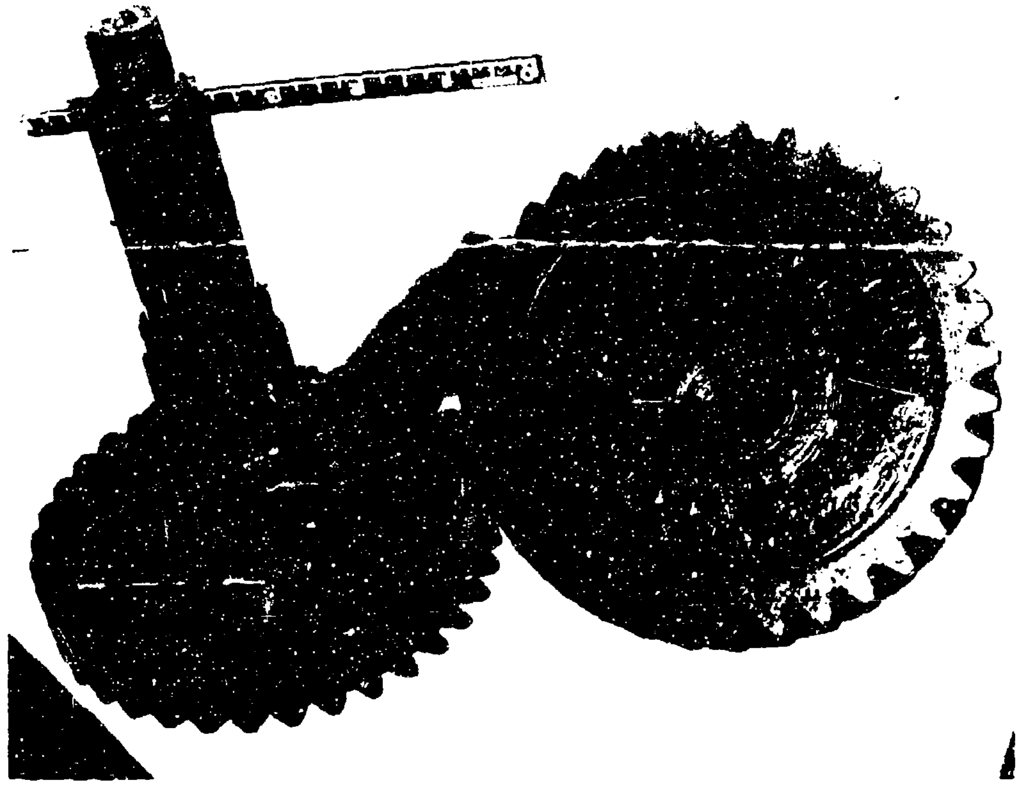

FIGURE 2. Effect of High Temperature Operation on Gear Lubricants.

Lubricating grease has a tendency to separate and oxidize when overheated. The condition of such lubricants should be checked after suspected overheating.

Batteries must be given special consideration because of the heat of the desert. The self discharge rate is higher and the sulfation rate is more rapid. In wet cell batteries, the electrolyte level and specific gravity must be checked frequently. Overcharging batteries will result in a higher evaporation rate of the electrolyte, so the voltage regulators should be set to the lowest possible charging rate consistent with overall requirements. On aircraft, a battery sump jar should be installed as a precautionary measure to accept overflow of electrolyte in the event of battery boiling.

Gaskets and seals deteriorate more rapidly in the desert due to the heat and solar radiation. Additional maintenance is generated by the necessity to replace them at shorter intervals.

Electrical cables and connectors can suffer deterioration due to heat and solar radiation; this is often aggravated by the rough handling to which they are often exposed. Connectors in particular, can become contaminated by sand and dust causing binding or breakage.

(3) Sand and Dust. Electrical relays in the aircraft system, avionics or armament subsystems may be made inoperative due to sand or dust particles on contacts. Sealed units should be used whenever possible.

Sand and dust represent the most significant adverse environmental consideration. Sand and dust penetrate every crack and crevice, contaminating and causing premature wearout of bearings, gears and other moving parts. Although sand and dust contamination is presented to some extent in most operating environments, it is particularly severe in the desert due to the lack of vegetation and moisture.

Air cleaners must be cleaned and inspected frequently to insure an adequate supply of clean air to engines. The frequency of these actions will depend on the particular conditions of weather and terrain encountered.

Components which utilize open hydraulic systems are subject to a rather peculiar difficulty which is aggravated by the airborne dust of the desert. Minute fungal spores are carried by this airborne dust and can settle in hydraulic systems when exposed or open for maintenance. Fungus growth has been observed in the form of a dark colored slush, usually at the bottom of hydraulic reservoirs where the hydraulic fluid forms an interface with small amounts of condensed water. The presence of this slush can clog hydraulic valves and filters as well as support corrosion. The growth of fungus in hydraulic systems can be largely prevented by the addition of fungicides or anti-icing additives.

Optical components of rocket and missile systems become dusty and require frequent cleaning in the desert. It is imperative that these devices be properly covered when not in use to reduce the requirement for cleaning.

b. Unique

(1) Environment. Water pumps will corrode rapidly if alkali water has been used in the cooling system. This should be prevented, but if "hard" water has been used, adequate replacement parts should be available.

Cooling fins on air-cooled engines should be kept clean and free from debris. Baffles should be properly adjusted to direct maximum airflow to the hot cooling fins.

Electronic and electromechanical components of missile systems are generally subject to the environmental stress, and might be expected to demonstrate higher failure rates. This has not been experienced in recent testing of rocket and missile systems due to the following factors:

(a) First, the temperature range of the desert environment has been well defined, permitting the reduction of heat related failures by providing adequate safety margins, derating of components and use of improved cooling techniques.

(b) Second, and probably more significant, modern rocket and missile systems are supported by environmental control systems which maintain temperature, pressure, humidity, and freedom from contamination. The successful operation of these environmental control systems effectively removes the missile system from the extreme heat of the desert. (Fig. 3) In addition, many subsystems are sealed units and safe from contamination by sand and dust.

Static electric charges are easily accumulated in the dry desert air. Static discharges have been observed to cause random errors in electronic circuitry. This has been particularly true in high density solid state packages such as computer memories.

The failures experienced in testing electronic equipment in a desert environment are typically different than those experienced in temperature, tropic or arctic areas. Testing personnel should be aware of the effect of the environment on various components in order to properly plan for replacement of failed components during test and for evaluation of test results.

Maintenance of ammunition and explosive items is normally limited to removal from packaging, inspection, preservation, marking and sometimes assembly or renovation In addition, some relatively complex items, e.g., proximity fuzes or land mines, may require additional maintenance on electrical components.

Generally, the maintenance requirements for ammunition and explosive items are considered to be somewhat reduced in a desert environment as compared with other common environments. Packing materials do not deteriorate rapidly in the desert. Requirements for preservation are reduced due to the low relative humidity which alleviates problems associated with corrosion and fungus. Markings may be obscured due to prolonged exposure to solar radiation requiring more frequent marking to maintain legibility.

FIGURE 3. ENTAC ATGM Missile. TOP. Guidance and Fire Control Package After Desert Exposure. BOTTOM: Missiles, Launcher and Shipping Containers After Exposure to Desert Environment.

The great majority of rockets and missiles intended for use by the U. S. Army undergo testing at White Sands Missile Range, New Mexico, and in some cases at the Army Air Defense Board, Fort Bliss, Texas. As both of these installations are located in marginal desert regions, considerable experience in operation and maintenance of such items under desert conditions have been acquired. The results is that modern rocket and missile systems are properly designed or protected for use in the desert.

The reliability of power generating equipment is often adversely affected by the desert environment. Often the reliability of a complete radar or communications system is severely reduced because of power failures.

(2) Heat. Particular attention should be given to vehicle cooling systems as overheating is one of the major problems of operation in the desert. The operator should frequently check the temperature gauge to determine proper operation. Severe damage to the vehicle can be caused by overheating; it is important that a test vehicle not be operated above safe operating temperatures. Liquid cooling system should be flushed and cleaned frequently. Distilled water should be used if possible, and a corrosion inhibitor should be added. The coolant level needs checking often due to the increased possibility of loss in the desert. The radiator pressure caps should be checked for proper operation as one pound of pressure raises the boiling point approximately three degrees. The exterior of the radiator should be cleaned to prevent the accumulation of sand and dust which restricts airflow and impedes cooling. Hoses deteriorate rapidly in the desert due to the extreme heat. They should be inspected at more frequent intervals than those prescribed in the technical manuals. Spares should be available.

Brake fluid conforming to the requirements of MIL-H-13910 has a minimum reflux boiling point of 302°F; however, the normal 3 to 4% absorbed moisture lowers the boiling point to 265-275°F.

Brake fluid conforming to the requirements of VV-B-680A has a reflux boiling point of 374°F which is lowered to about 300°F by moisture absorption. The heat tolerance of the current synthetic rubber brake cups further limits the maximum safe operating temperature to 265°F for sustained operation although temperatures as high as 300°F can be tolerated for short periods (not exceeding 15 minutes).

Frequent bleeding of hydraulic systems may be required to maintain pressure. This is due to the great diurnal temperature variations experienced in the desert. A 30-degree difference between morning and afternoon temperatures is common. Equilibrators may need adjustment to maintain proper gas pressure balance due to the same conditions.

Conventional warheads for some missile rounds are heat sensitive. The solid explosive materials can melt and/or deteriorate chemically if their temperature is permitted to reach about 155°F. This can result in a serious safety problem.

High temperatures cause decomposition and dielectric failures in electrolyte and paper capacitors. In addition, temperature rises result in increased dc leakage current in electroyltic capacitors. This, in turn, causes increased heating and drying out of the electrolyte resulting in rapid failure of the device. Although air dielectric capacitors are virtually immune to high temperature effects, variable air capacitors may lose lubrication in bearings or become contaminated by foreign particles (sand and dust) causing shaft seizure.

The useful life of most resistors is shortened by exposure to high temperature environments. Power dissipated by resistors is given up in the form of heat to the surroundings. If the surroundings are also hot, the efficiency of heat dissipation is reduced and the capacity of the resistors is limited. Variable resistors can become contaminated by sand and dust causing difficulty in adjustment. In addition, high temperatures cause the lubricants used in all variable resistors to dry up, ooze out, or migrate from the bearings to other surfaces.

High temperatures reduce the life of transformers. Insulation deteriorates and the resistance of the windings increases, changing transformer characteristics. In addition, mechanical damage to transformers may result from changes in transformer temperature. This can be particularly serious in the desert due to large diurnal temperature cycles.

In vacuum tubes, high temperatures can result in grid emission and release of gas from other tube elements. Electrolysis of leads coming through the glass envelope can also occur. As the bulb temperature increases, the life of a tube is markedly decreased. Figure 4 shows average test life survivals of typical tubes as a function of bulb temperature.

Transistors and other semiconductor devices are extremely sensitive to heat problems. As semiconductor material is subject to heat and solar radiation, the number of available charge carriers is increased. These, in turn, create more heat and thermal runaway resulting in total destruction of the device. It is imperative, therefore, that semiconductor devices be operated at temperatures below their design limitations. The trend toward miniaturization also accentuates heat intensity problems in electronic equipment by concentrating heat producing elements such as semiconductors, transformers and resistors.

The intense heat and solar radiation can cause considerable damage to aircraft and subsystems. Structural surface temperatures are dependent on the heating effect of the sun and whatever cooling effect

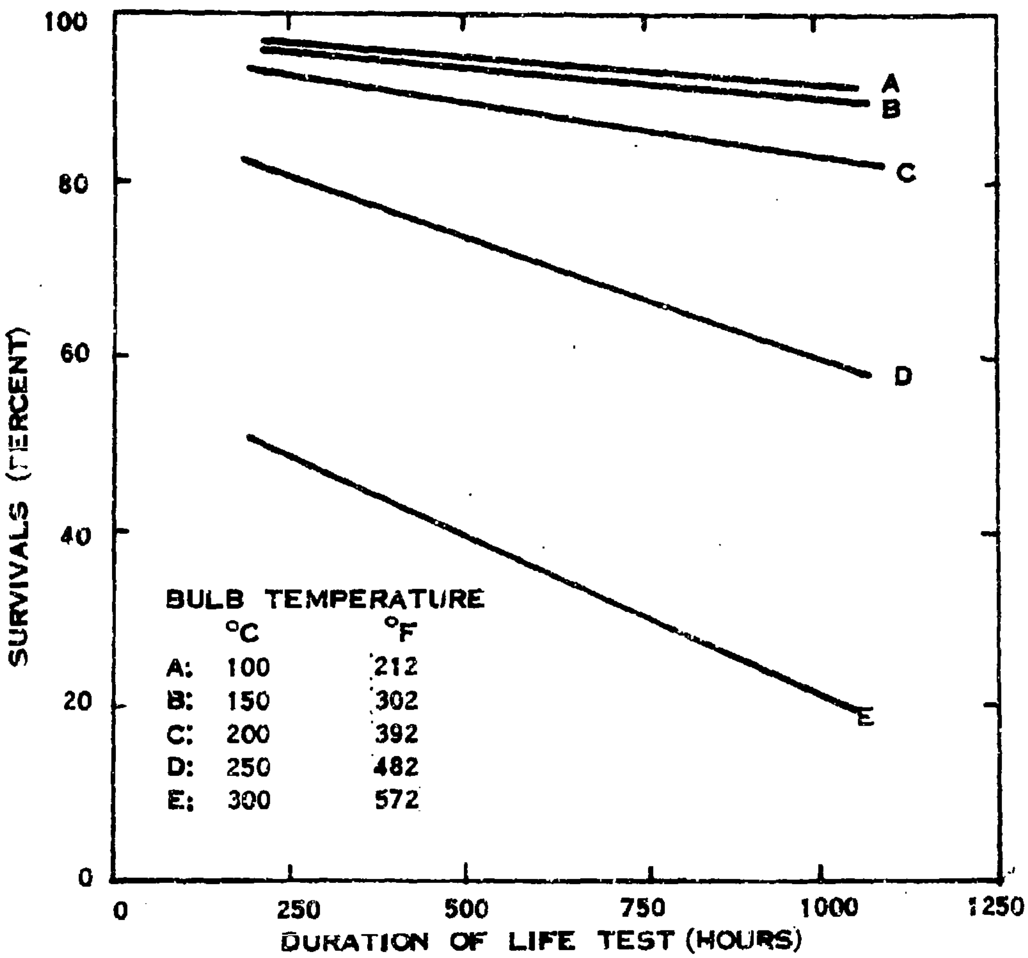

FIGURE 4. AVERAGE LIFE TEST SURVIVALS OF TYPICAL TUBE VS BULB TEMPERATURES.

the wind may exert. Calm air may permit surface temperatures up to 1.5 times the ambient air temperature in degrees Farenheit. Interior temperatures depend largely on ventilation. With proper ventilation, the interior temperature can be reduced to within a few degrees of ambient but much higher temperatures will result if ventilation is inadequate.

Avionics, communications and electronic components of fire control subsystems are easily damaged by exposure to intense heat and solar radiation. Some improvement has been effected by painting the cowling over critical components with reflective (white) paint. Temperature reductions of 7 to 15°F have been achieved in this way.

Fan belts also deteriorate at an increased rate in the desert due to heat and the abrasive effects of sand and dust. Frequent inspection, adjustment and replacement should be anticipated.

Tires and track pads are damaged by the rough terrain. Excessive temperatures can be generated by a combination of ambient heat, radiation and friction. Rubber track pads have been known to blow out due to concentration of heat in the interior of the rubber. Temperatures of tires and track pads should be kept below approximately 250°F. (See Fig. 5)

(3) Sand and Dust. The adverse effect of the desert environment on maintenance requirements of armament and individual weapons is primarily due to blowing sand and dust. Moving parts in the recoil mechanism, brakes, elevating and traversing mechanism can easily become contaminated by foreign particles. This leads to a higher rate of wear for the affected parts. The problem is often compounded if the moving part or sliding surface is lubricated, as the lubricant will cause the particles to adhere to the part, forming an abrasive paste. It is noteworthy that the sand and dust particles considered here are not necessarily due to wind but may be due to nearby activity of vehicles and personnel, or to muzzle blast from the weapon itself. (See Fig. 6) Sand and dust are particularly difficult problems in small caliber weapons and result in high wear, clogging and jamming

Blowing sand results in abrasion of exposed surfaces. The weapon should be inspected periodically to determine the condition of such surfaces and the need for protective coatings. When the weapon is not being used, it should be protected from the environment by covering vulnerable parts. Use VPI paper, FSN 8135-097-5245, inside tubes and barrier paper, FSN 8135-282-0565, outside tubes during storage to prevent corrosion. Greaseproof (wax) paper often breaks down due to high temperature. Reference should always be made to the appropriate technical manual section on "Operation Under Unusual Conditions" for specific instructions.

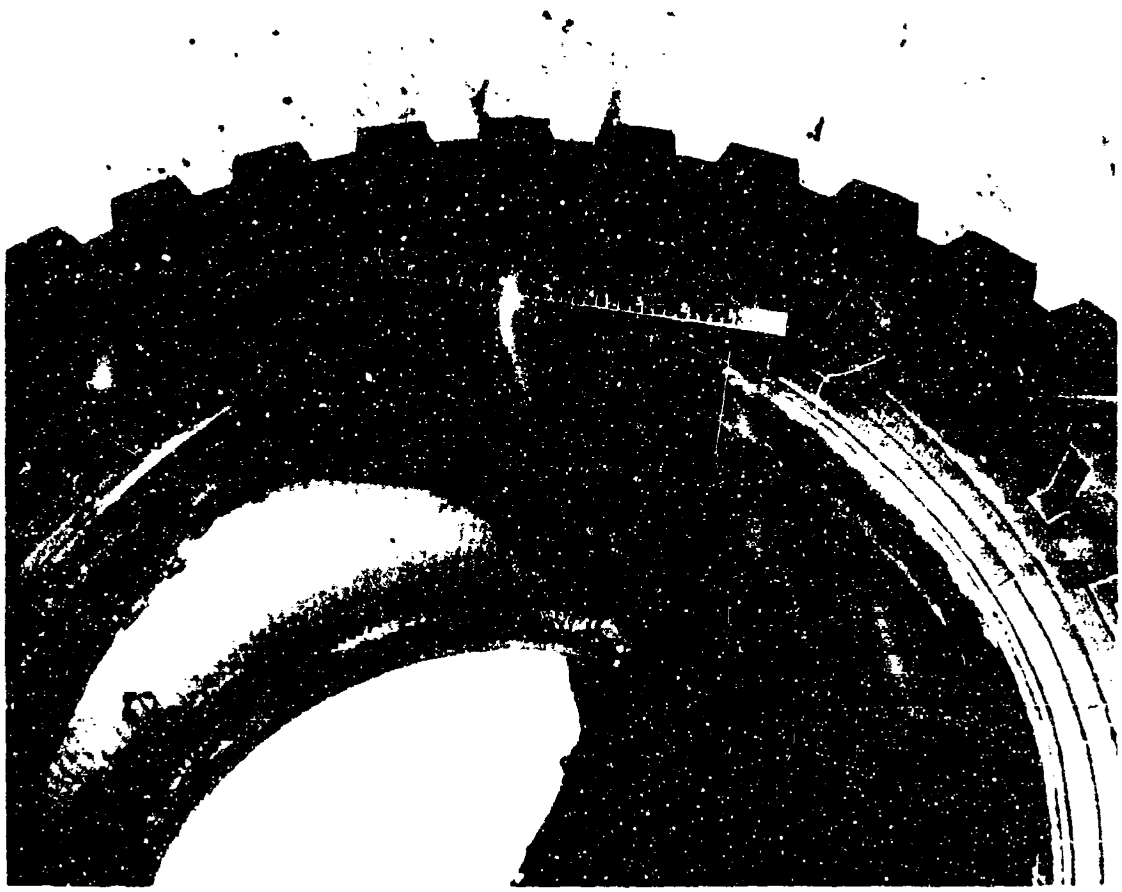

FIGURE 5. Damaged Tire Resulting From High Temperature Conditions.

Relays and contactors are easily contaminated by sand and dust preventing contacts from closing. In addition, the combination of heat and solar radiation can deteriorate coil insulations and moldings.

In addition to contamination of moving parts, blowing sand is responsible for pitting of transparent materials such as plastic windows. Numerous window covering devices have been used but none have been found to be very effective in the desert. Frequent inspections and cleaning are necessary and a higher than normal replacement rate should be anticipated. Contamination of sliding window channels, causing binding and difficult operation, has been a particularly frequent problem in the past, as have seat adjustment mechanisms.

Erosion of helicopter rotor blades and turbine engine compressor blades has also been reported frequently. These are inherent problems in the desert but can be alleviated somewhat by operation from frequently swept hard pads and by avoiding low level hovering.

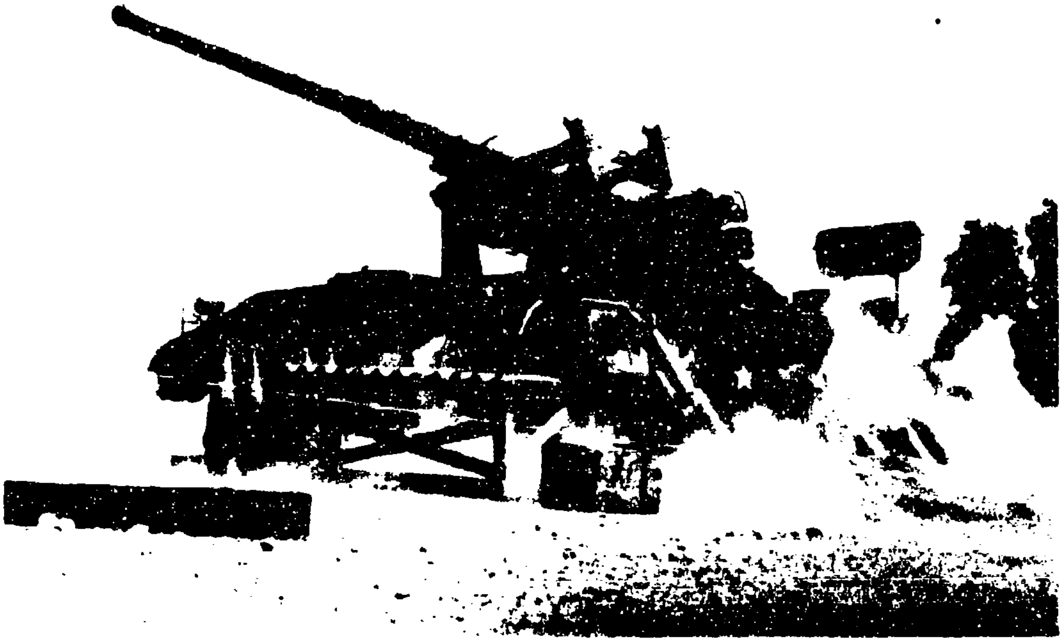

FIGURE 6. Muzzle Blast

The sand and dust can also contaminate aircraft armament subsystems and components such as weapons, sighting mechanisms, ammunition chutes and storage boxes. Frequent cleaning may be required to reduce jams and insure proper operation.

5. Maintenance Problems.

a. General

(1) Environment. All maintenance of test items should be performed according to the instructions in the proper technical manual. However, the instructions in the manual may have to be modified based on incompatibility with the desert environment or other factors. Recommended changes to publications should be submitted to the indicated agency on DA Form 2028.

The degree to which the desert environment hinders the actual performance of maintenance or army materiel is heavily dependent on the type of facilities available.

(a) On wheeled and tracked vehicles, operator or crew maintenance is performed on the road, off the road, or wherever the vehicle happens to be at the time maintenance is required. No shelter is normally available. Tools, parts, and technical publications are limited to those which are carried on the vehicle. The effect of the environment is greatest at the operator/crew level. Windblown sand and dust can contaminate fuel, oil or other fluid reservoirs while they are being checked or filled. Care must be taken to insure that exposure to such contamination is minimized. Exposed lubricated surfaces can quickly become contaminated by sand and dust particles. This not only destroys the value of the lubrication but forms an abrasive paste which will often result in rapid wearout. Tasks which require exposure of lubricated surfaces should not, therefore be performed under adverse desert conditions.

(b) Aircraft maintenance should be performed in a protected environment whenever possible. Shade and protection from blowing sand and dust are often provided by a hangar. If the facilities of a hangar are not available, maintenance should be performed with the protection of some sort of a shelter or lean-to in order to block the wind. Canopies may be used to shade the aircraft.

Under desert summer conditions, maintenance personnel working hours should be scheduled to avoid the hottest part of the day whenever possible. In poorly ventilated areas, personnel should work in pairs as a precaution in the event of heat exhaustion. It should be noted that the efficiency and error rate of maintenance personnel is a function of temperature (See Fig. 7).

Maintenance personnel should be familiar with the problem of static electrical discharges in the operation of electronic test equipment. A satisfactory method of reducing this problem is to discharge static electricity before handling sensitive equipment. This may be accomplished by touching some point of ground potential with a key or non-insulated metal tool before touching sensitive test equipment. In addition to reducing random equipment errors, this procedure eliminates human discomfort associated with the "shock" of static discharge.

Small portable items of test equipment provided to organizational maintenance units should be kept as clean as possible and shaded from direct sunlight whenever this is compatible with operational considerations.

Organizational and higher category maintenance is normally performed with the side of some sort of a shelter, often a tent or temporary building. The shelter should be effective to some degree in reducing the adversity of the environment (See Fig 8). The heat and solar radiation problems are diminished when maintenance is performed in a tent or temporary shop. It is, nevertheless, important to be aware of the

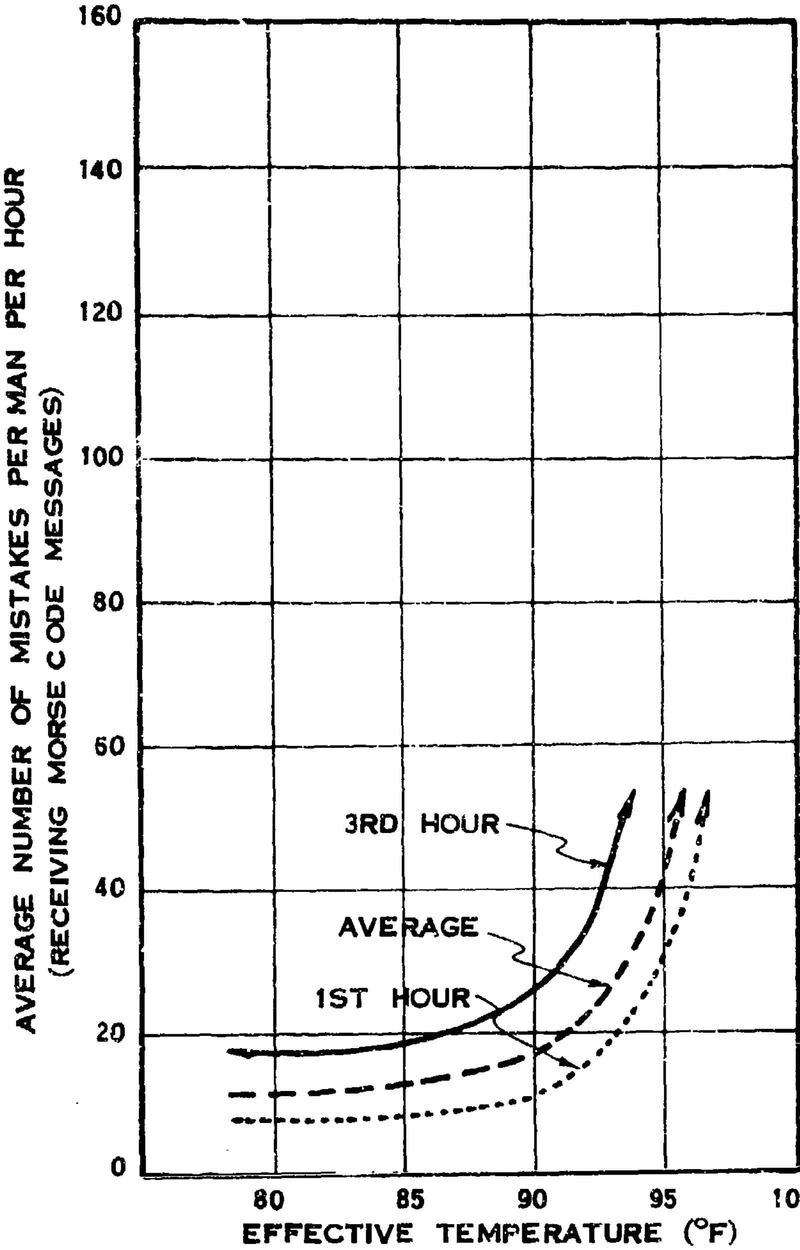

FIGURE 7. EXAMPLE OF ERROR INCREASES DUE TO TEMPERATURE RISE.

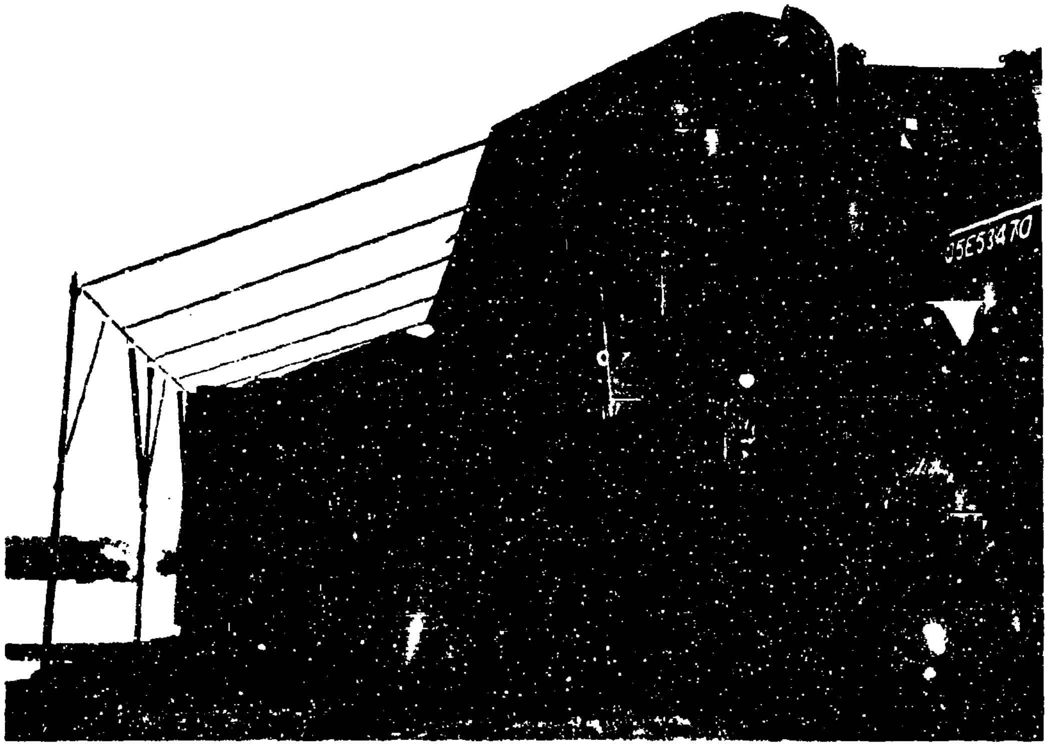

FIGURE 8. Organizational Maintenance Shop

continued limitations of personnel due to heat in the shelter. Vehicle components may still be very hot and require the use of protective gloves by personnel. Sand and dust may have accumulated on the vehicle to a sufficient degree to present a contamination problem even though the wind may no longer be a factor.

More complex systems require maintenance at organizational, direct support and general support in the field. Organizational maintenance again is limited to periodic cleaning, diagnosing malfunctions to major modules using simple, easy-to-interpret, go no-go checks, and replacement of major modules. Direct support and general support maintenance consists of detailed checkout and diagnosis of malfunctions, normally using special purpose automatic or semi-automatic test equipment which is installed in a maintenance shelter. Repairs are made by removing and replacing modules, components or interconnecting wiring. Defective modules are returned to depot for repair. Complete self-checking capability is provided for the test equipment.

(2) Heat. Components, tools, vehicle parts, and test equipment can become literally too hot to handle without protective gloves. The use of gloves can impede the finter movement and make fine adjustments or handling of small parts very difficult. Handles of tools may be wrapped with tape to provide better thermal insulation.

The effects of heat, solar radiation, glare, blowing sand and dust severely limit the efficiency of maintenance personnel. Sun stroke and heat exhaustion are ever-present hazards to persons performing maintenance work in the desert. The presence of high winds and blowing sand and dust can create an environment which makes certain maintenance tasks impractical if not impossible, due both to human discomfort and to the hazard of materiel damage. In addition, the operational efficiency of personnel is greatly reduced by heat. Figure 7 illustrates the increase in the average number of mistakes as the temperature increases. The mistakes indicated were errors in receiving Morse Code messages. See Reference 8 for further information. It should be noted, however, that a man can tolerate a much hotter temperature with dry air than he would be able to tolerate if the air were humid. High levels of glare may impair the vision of maintenance personnel, causing general discomfort and increasing the likelihood of mistakes or accidents. The glare of bright sunlight can interfere with maintenance tasks, as when detailed procedures from technical manuals must be followed.

(3) Sand and Dust. Sand and dust can be a serious irritant in the desert. Breathing can be impaired, particles can get into the eyes and irritate the skin. The severity of sand and dust hazards depends greatly on wind velocity and terrain.

Particular care should be taken to correctly clean optical components of missile fire control systems. Instruction in appropriate technical manuals should be followed. Optical lenses are easily scratched by sand particles so it is necessary to preclean optical surfaces with forced air and to wipe with clean cloth or tissue.

b. Unique

(1) Environment. Proper system maintenance is highly dependent on the correct functioning of direct support and general support test equipment which requires a cool, clean environment. This environment is provided by air conditioning and filtering systems which are integral to the maintenance shelters. It is imperative that these environmental control systems be properly maintained in order to preserve the required test equipment. In the event of failure in the air conditioning system, all electronic test equipment should be turned off in order to prevent overheating and multiple electronic component failures.

The degree of maintenance difficulty imposed by the desert environment is highly dependent on the maintenance facilities available. Often, facilities are determined by specific characteristics of the primary electronic equipment. Field radios, for example, receive first category maintenance from the user. Normally, this is limited to cleaning, replacing batteries and fuses. This limited maintenance is performed wherever the radio is located, and is subject to all of the adverse effects of the desert.

At the other extreme, certain communications equipment requires a clean, air-conditioned facility for operation and virtually all maintenance is performed in an artificial environment almost completely insulated from the desert.

In between lie a wide variety of temporary buildings, vans and trailers which offer some protection from the adverse effects of the desert environment while not removing them completely. The degree of isolation provided by these maintenance facilities depends heavily on their proper upkeep. Cleaning and servicing of air conditioners, ventilating fans, air filters and similar items must be performed in addition to good shop housekeeping in order to retain the degree of protection initially afforded by such facilities. Most of these cleaning and servicing tasks are performed (or neglected) by electronics maintenance personnel. Many maintenance problems have been experienced because the maintenance environment was permitted to degrade below that established in the maintenance concept. These problems include the effects of heat and contamination by sand and dust of both materiel and personnel.

The actual maintenance on armament and individual weapons which is performed at the crew and organizational level is normally limited to periodical inspection, cleaning, lubricating, and replacing major subassemblies (modules) for which special tools and test equipment, complicated adjustments or special skills are not required. Much of this maintenance is performed at the field location where the weapon is used. Maintenance facilities are primitive and often nonexistent. Maintenance may cause the exposure of internal operating parts to sand and dust.

Test measurement and diagnostic equipment (TMDE) which is necessary for maintenance of avionics, communications and other electronic equipment is, in itself, electronic equipment requiring calibration, inspection and other maintenance tasks. Problems described under Maintenance Requirements also apply to TMDE. These problems may be particularly severe due to accuracy requirements for TMDE and due to the use of many general purpose instruments in an environment for which they are not designed. Technical manuals or manufacturer's manuals should be consulted to determine the accuracy and limitations of all test equipment to be used in a hot or contaminating environment.

(2) Sand, Dust and Heat. Difficulties in performing maintenance on ammunition and explosive items in the desert environment are basically of two types. Sand and dust can cause problems in mating ammunition components, this can be alleviated by proper use of protective plugs and covers. In addition, maintenance personnel may experience difficulties working in the desert due to heat, blowing dust, glare, contact with hot materials and other human factors associated with the desert.

All possible ground checks should be made prior to starting an aircraft engine. Particular attention should be directed to cleaning and checking such items as landing gear shock struts, wheel brakes, tires, draining and ventilating holes, operating controls, instruments, dials and switches. The cabin ventilating fans should be started as soon as possible after power is connected. Avoid contact between foreign objects and plexiglass windows or canopy as this material is easily damaged during extremely high temperatures.

Engines should be run up on a hardstand or where the least sand and dust exist. The aircraft should be pointed into the wind with no other aircraft or personnel downwind from it. Use restraint while priming engines because of the high evaporation rate. All temperature limitations should be observed and the complete ground test should be accomplished as rapidly as possible to avoid overheating.

The aircraft should not be taxied more than absolutely necessary in order to prevent sand and dust erosion and contamination as well as to prevent overheating of brakes. A tow vehicle should be utilized to move the aircraft, as desired, at low speeds.

After flight, the aircraft engines and other critical components should be covered as soon as possible. Parking brakes should be applied only after the brakes have cooled. Aircraft and components should be cleaned and checked with particular attention directed to the following: control cable tension, air filters, oil consumption, tire pressure, compass fluid level, oleostrut pressure and engine inlet. Purging of bearings may be necessary to force out foreign abrasive materials. Rotor blades and propellers should be checked for damage after each flight.

Extreme care should be exercised when refueling or otherwise handling engine fuel at temperatures above 120°F to prevent sparks and explosion. Adequate grounding of aircraft and fuel delivery system is imperative. Lubricating oil should be delivered directly from the can to the oil tank without an intermediate measuring can or open container. This should reduce the possibility of contaminating the oil before delivery to the aircraft.

TM 1-13A9-1-2 should be used as a guide for installation, removal, cleaning, repair, treatment and storage of aircraft protective covers.

6. Maintenance Evaluation.

a. General

Personnel performing a maintenance evaluation as part of a TECOM test should be thoroughly familiar with the contents of TECOM Regulation 750-15. It is the purpose of the maintenance evaluator to assess not only the vehicle maintenance performed during the test, but also the vehicle design and maintenance package. In tests conducted in the desert, every effort should be made to correctly evaluate the adequacy of the entire system, vehicle plus maintenance package, to insure efficient performance of maintenance in the desert environment. Data organization should permit comparison of desert test results with the results of other tests on like items. General information pertinent to the revised Army Maintenance Concept can be found in DA Circular 750-34 (Maintenance Support Positive).

Particular attention should be given the following:

(1) All maintenance requirements, failures and malfunctions should be analyzed to determine cause and whether the particular incident was induced by environmental factors (especially, desert environment) or whether poor design or workmanship was at fault.

(2) Tools and test equipment should be evaluated in the maintenance environment. A determination should be made as to possible degradation of tools and test equipment, as well as their interface with the test item and maintenance personnel, under conditions of heat and contamination.

(3) The effect of the desert environment is most severe on operator/crew and organizational maintenance personnel. The evaluator should examine the Maintenance Allocation Chart (MAC) and the Repair Parts and Special Tools List (RPSTL) as well as the technical manual instructions and mechanic's comments to determine if maintenance tasks have been assigned to the proper maintenance level. In making the above determination, consideration should be given to the desert environment as well as the availability of required tools, test equipment and spare parts. The entire maintenance system is to be evaluated: hardware design, tools, test equipment parts, publications, storage compartments, human factors and safety aspects of maintenance as well as the interface with the maintenance evironment.

(4) Procedures should be evaluated to determine if they are appropriate to the conditions encountered in the desert.

(5) Repair parts and the Maintenance Allociation Chart should be examined to determine if installation is specified at the proper maintenance level. Those parts experiencing high mortality during desert testing should be identified.

(6) The vehicle design for maintainability should be evaluated with the maintenance conditions encountered in the desert for background.

(7) Safety and human factors aspects of maintenance operations should be evaluated with particular attention given to maintenance personnel touching hot vehicle components and tools in the performance of tasks.

Maintenance evaluators should investigate the possibility of using differing grades of lubricants, hydraulic fluids, protective devices and finishes if these would be more suitable to desert operation.

The requirements for scheduled maintenance, cleaning, inspecting, lubricating and time component changes may be significantly altered in the desert environment. The maintenance evaluator should recommend such changes as necessary.

In addition to collecting operational and maintenance data, the evaluator should identify environmental factors which may affect test results; i.e., failure modes and repair time. He should understand the maintenance concept for the particular system.

Scheduled maintenance intervals and tasks to be performed at these intervals should follow the approved technical manuals for the system in question. The evaluator should recommend changes to these intervals and procedures which would improve system operation maintenance. These changes may be necessitated by environmental considerations, personnel training or skill considerations, logistics, or tool and test equipment availability.

Adequacy of maintenance shelters and associated environmental control systems and power sources should also be evaluated. Degree of evaluation will depend on the scope of the test.

Personnel responsible for maintenance evaluation of electronic test items should attempt to identify elements of operational and maintenance data which have been affected by the test environment. This applies to maintenance task time as well as to failure analysis.

A formal maintenance evaluation is rarely performed on ammunition and explosive materiel. Testing personnel should nevertheless make certain that the test items, technical manuals, tools and the overall maintenance concept are consistent and compatible with the desert environment factors.

b. Unique

The scope of maintenance evaluation performed on aviation, air delivery and aircraft weapons subsystems test items depends largely on

its maintenance significance. The maintenance evaluation to be performed during the test of a cargo sling or parachute system might be very limited, while an extensive maintenance evaluation would be required for an aircraft or major weapon subsystem.

Operator/crew maintenance on aircraft and weapons subsystems is normally limited to pre-flight and post-flight checks.

Organizational maintenance personnel normally perform testing, cleaning, lubricating, tightening, adjusting, safety wiring, inspection and other preventive maintenance tasks. Troubleshooting should consist of isolating malfunctions to a replaceable module or component using the technical manual, troubleshooting instructions and easy-to-interpret go no-go tests, built-in test equipment (BITE), aircraft instruments, or other easy-to-use diagnostic devices. Servicing aircraft is also organizational responsibility.

An effort should be made to evaluate diagnostic routines used to localize and isolate malfunctions in a missile system. Much of the automatic test equipment evaluation is normally based on its ability to properly identify faults which were deliberately introduced for this purpose. It should be recognized that the selection of these faults play an important role in the design of a test. It is possible for an individual who is familiar with the diagnostic programs to introduce faults in such a way as to bias the test results. For this reason, induced faults should be selected based on historical data, experience with similar systems, or completely at random. Appendix A of MIL-STD-471 shows one useful method for fault selection. Many others exist. Selected faults should be as representative as possible and completely unbiased in order to provide a meaningful test. Naturally occurring faults should be included (even emphasized) in the test results as these are probably the most representative.

Recommended changes to this publication should be forwarded to Commander, U. S. Army Test and Evaluation Command, ATTN: AMSTE-ME, Aberdeen Proving Ground, Maryland 21005. Technical information related to this publication may be obtained from the preparing activity (Commander, Yuma Proving Ground, ATTN: STEYP-MMI, Yuma, Arizona 85364). Additional copies of this document are available from the Defense Documentation Center, Cameron Station, Alexandria, Virginia 22314. This document is identified by the accession number (AD No.) printed on the first page.

APPENDIX A
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